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(54) Improvements relating to pumps or motors

(57) A pump has pistons (5) which are moved with constant velocity during the working stroke to produce constant delivery. In one form, a rotary cam (2) operates the pistons via followers (8) and interconnected actuators (6), the cam profile being such that, when it is rotated at constant angular velocity, the pistons move with constant linear velocity. Another version has fixed cam surfaces with which followers diametrically sliding on a rotor cooperate. The followers have a pin and cross-slide connection to the piston rods the geometry again producing constant linear velocity for the pistons from constant angular velocity from the rotor.

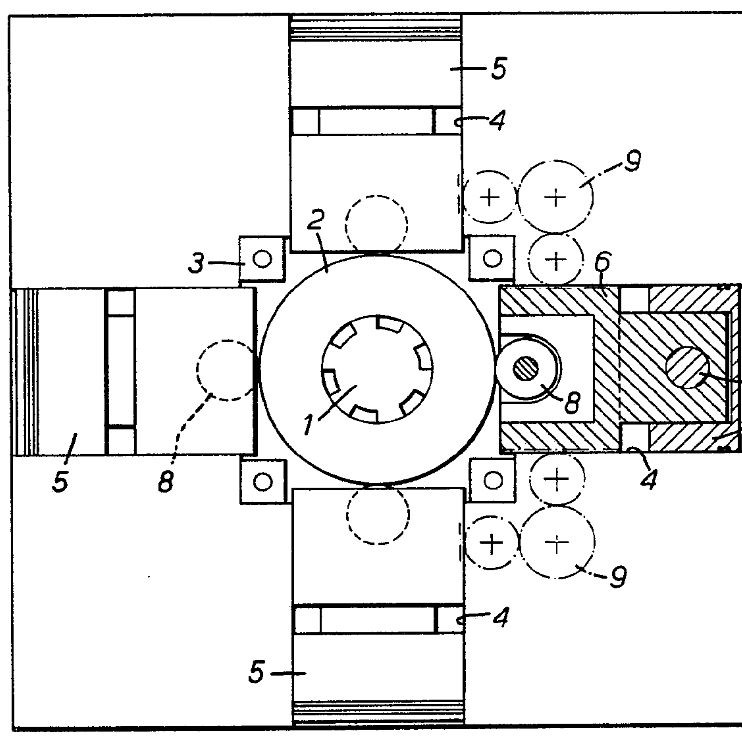

FIG. 1.

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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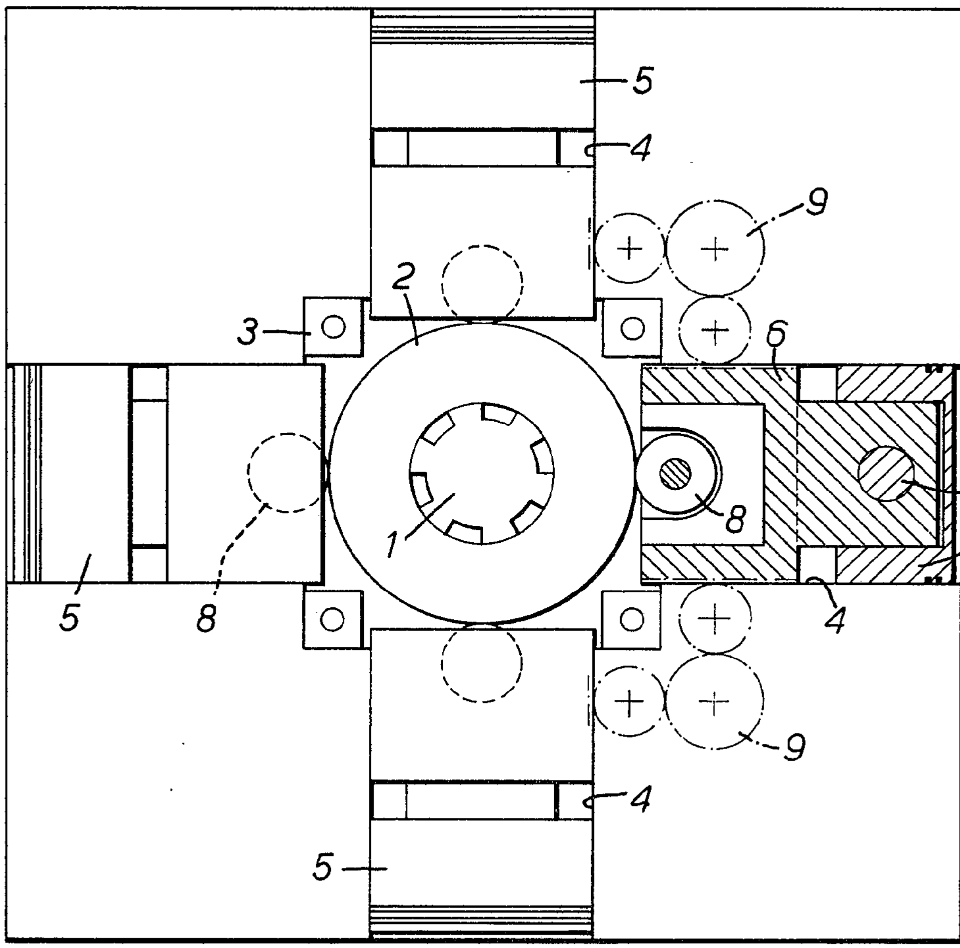

FIG. 1.

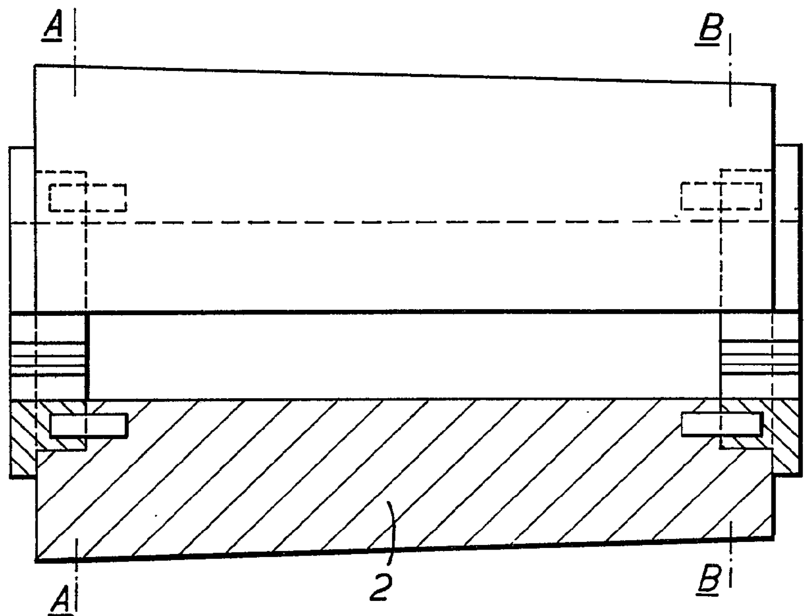

FIG. 2.

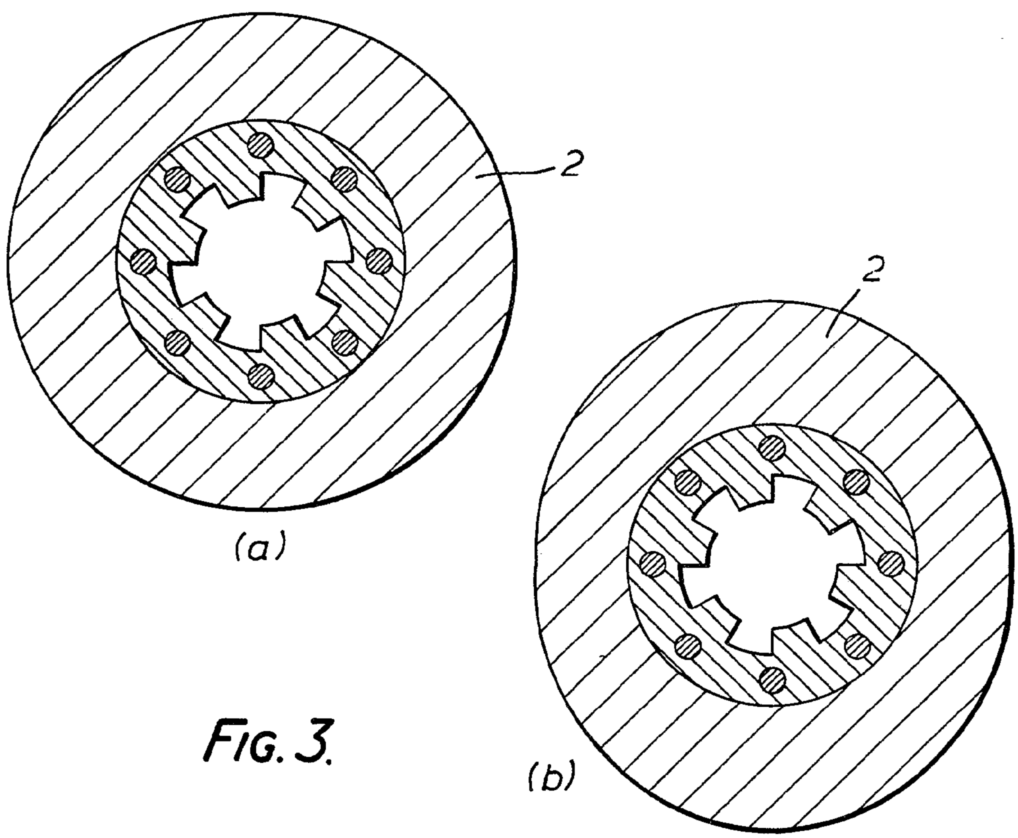

FIG. 3.

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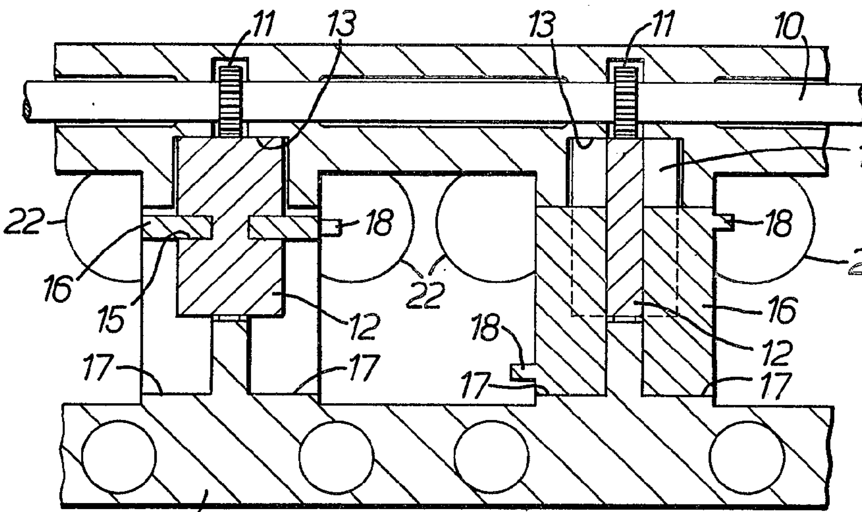

FIG. 4.

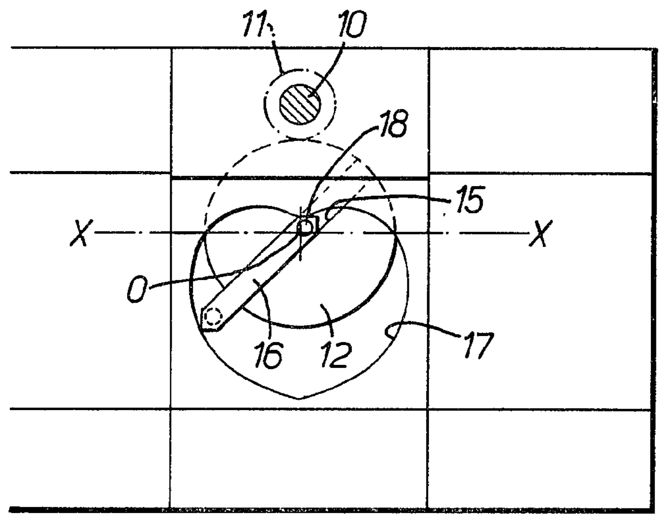

FIG. 5.

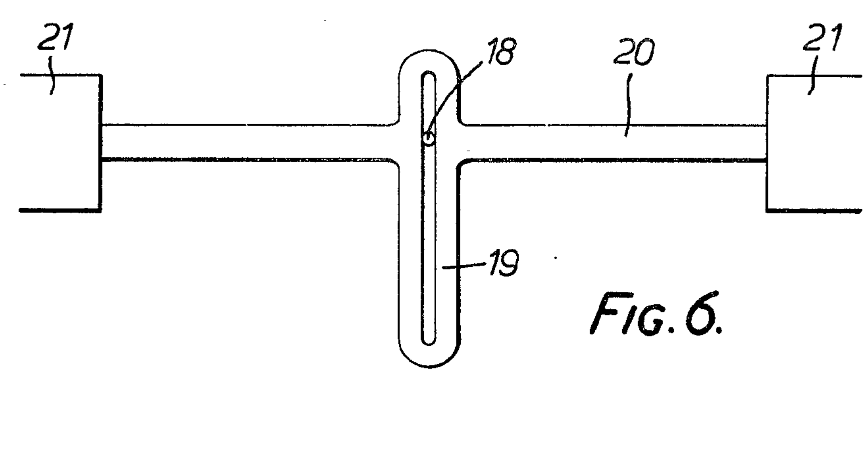

FIG. 6.

SPECIFICATION

Improvements relating to pumps and motors

This invention relates to pumps and motors. It is primarily intended for application to a pump which drives a motor in a hydraulic transmission system.

There are many different kinds of hydraulic pumps, but a problem with many of them is that they do not produce an even flow. If the pump has pistons, each piston is generally driven from a rotary prime mover whose motion is translated into linear reciprocation with a sinusoidal characteristic. In simple terms, the piston slows at each end of its stroke from a maximum at the middle, so producing variable flow. With a number of staggered pistons, the uneven flow can be smoothed out to a considerable extent, but the more pistons there are, the greater the complexity and expense of the pump.

It is therefore the aim of this invention to provide a pump of simple construction in which substantially even flow can be obtained from each piston throughout its working stroke.

According to one aspect of the present invention there is provided a pump operated by rotary cam means, the cam profile being such that there is substantially constant delivery throughout the piston stroke when the rotation is at constant velocity.

In one preferred form the cam means comprises a rotary cam member and a cam follower on a piston actuator co-operates with said cam member. There may be two opposed pairs of pistons and a symmetrical cam between them acting on the piston actuators. The common axis of one pair will be at right angles to that of the other pair, and both axes will be aligned onto the axis of rotation. While the pair of pistons performs a delivery stroke, the opposite pair will be on an intake stroke.

In order to achieve a variable transmission, assuming the pump drives a hydraulic motor, the cam may be axially movable to present to the followers various different profiles, but all having the characteristic of generating constant delivery. One profile can be a circle centred on the axis of rotation: this will be the neutral position in which no liquid is pumped.

In another version, a rotor carries a follower which co-operates with a fixed cam surface. This follower is linked to a piston rod in such a manner that constant velocity is achieved for a working stroke.

Another aspect of the present invention consists in reversing such a pump to serve as a hydraulic motor.

For a better understanding of the invention, one embodiment will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross section of a hydraulic pump.

Figure 2 is a longitudinal section of the pump of Fig. 1.

Figures 3(a) and 3(b) show the shape of parts of a cam used in the pump.

Figure 4 is a diagrammatic cross section of another pump.

Figure 5 is a section on the line V–V of Fig. 4, and

Figure 6 is a detail of the pump of Fig. 4.

The pump of Figs. 1 to 3 has a splined input shaft 1 which is rotated at constant speed by a prime mover (not shown). A cam 2 of generally cylindrical form is mounted on this shaft to rotate with it by virtue of the spline but it can be moved axially by means of a yoke 3. The cam profile will be discussed below. Evenly spaced around the shaft 1 there are four cylinders 4 containing pistons 5 whose axes intersect at right angles on the axis of the shaft 1. Each piston has an actuating member 6 to which it is linked by a pin 7 and guided for co-axial movement. At the radially inner end, each member 6 carries a cam follower in the form of a roller 8, and each adjacent pair of members 6 is coupled by a transmission (here exemplified by a gear train 9 and rack formations on the members 6) which ensure that as one piston moves radially outwards the opposite one also moves outwards and the adjacent ones inwards.

Referring to Figs. 2 and 3, the cam profile varies smoothly throughout its length. At one end it is circular as shown in Fig. 3(a). This is the neutral position producing no piston movement. At the other end (Fig. 3(b)), each quarter of the profile has a shape which can be expressed in polar co-ordinates as:

$$r = a + b\,\theta$$

In other words, each quarter profile is part of a spiral which increases in radius uniformly with the angle subtended with the base line.

In between the ends of the cam there are similar but less eccentric profiles. Referring to the above formula, *a* and *b* take different values along the length of the cam, but their relationship is such that the cam followers 8 remain in contact throughout each cam revolution, whatever cam profile is being used. Thus, as the shaft 1 rotates at constant speed so the pistons 5 are moved at constant speed within the cylinders 4. They do so throughout each stroke, and therefore there is constant flow. Opposed cylinders will be combined, and valves (not shown) synchronised with the shaft 1 will alternate the cylinder pairs for intake and delivery.

An alternative pump, which can also be used in the reverse mode as a motor, driven by a similar pump or one corresponding to that of the previous figures, is shown in Figs. 4,5 and 6. A drive shaft 10 has two pinions

11 which drive external gearing on cylindrical rotors 12. These are shaftless, and run in cylindrical guide surfaces 13 in the main body 14. Each rotor has a diametral groove 15 in each circular face, the grooves being parallel on each rotor, but those on one rotor are at right-angles to those on the other, as best seen in Fig. 4. Each groove receives a bar 16 which can slide longitudinally therein. The ends of each bar engage an associated heart shaped cam surface 17 formed in the valve body 14 and, as the rotors turn, so the bars move back and forth in their grooves. Each bar has a projecting pin 18 near one end and this engages in a cross-slide 19 in a piston rod 20 with pistons 21 at each end, as best seen in Fig. 6. The pins 18 are at opposite ends on opposite sides of each rotor. The positions of the cylinders are indicated by 22 in Fig. 4. The reciprocal and rotational motion of the bar is transformed into a reciprocal motion of the piston rod and the geometry is such that uniform velocity of the piston rod is maintained throughout a 180° turn of the rotor, assuming that is also rotated with uniform velocity. The other half cycle necessarily produces non-uniform velocity of the piston rod but this can be used for the intake rather delivery stroke.

In Fig. 5, the uniform working stroke is generated by the double curve forming the top of the 'heart' above the line X–X, the latter representing the common cylinder axis passing through the rotor axis O. In polar co-ordinates, assuming the working stroke is of length 2S, the path of the pin 18 is:

$$r = S \sec \theta \left(1 - \frac{2\theta}{\pi} \right)$$

With the bar and pin arrangement shown, the four cylinders will be working cyclically, with a 90° phase shift between them. Valve systems can be provided whereby, at the end of a discharge or working stroke from one cylinder, it is instantaneously switched for intake, for example of return fluid from a hydraulic motor, while at the end of the return stroke the valves are reversed.

CLAIMS

1. A pump having a piston operated by rotary cam means, the cam profile being such that there is substantially constant delivery throughout the piston stroke when the rotation is at constant velocity.

2. A pump as claimed in Claim 1, wherein the cam means comprises a rotary cam member, and a cam follower on a piston actuator cooperates with said cam member.

3. A pump as claimed in Claim 2, wherein there are two opposed pairs of pistons and a symmetrical cam between them acting on the piston actuators.

4. A pump as claimed in Claim 3, wherein the common axis of one pair is at right angles to that of the other pair, and both axes are aligned onto the axis of rotation.

5. A pump as claimed in Claim 2,3 or 4, wherein the cam member is axially movable to present to the followers different profiles.

6. A pump as claimed in Claim 5, wherein one profile is circular, centred on the axis of rotation.

7. A pump as claimed in Claim 1, wherein the cam means is a rotor carrying a follower which cooperates with a fixed cam surface, the follower being linked to a piston rod.

8. A pump as claimed in Claim 7, wherein the follower is diametrically guided on the rotor and has a pin which engages a cross-slide on the piston rod.

9. A pump as claimed in Claim 7 or 8, wherein there are four such followers and associated pistons, the arrangement being such that the latter operate at 90° phase intervals.

10. A pump substantially as hereinbefore described with reference to the accompanying drawings.

11. A motor, being a pump as claimed in any preceding claim reversed.

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